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Patent 0-06-165 (16708/US/05)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor:	Yerushalmi-Rozen
Serial no.:	10/587,113
Filed:	June 25, 2008
Title:	METHOD FOR THE PREPARATION OF DISPERSIONS OF CARBON NANOTUBES
Examiner:	Vickey Marie Nerangis
Art Unit:	1796
Confirmation:	9526

Commissioner for Patents
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Dear Sir/Madam:

Response and Amendment

This response is in reply to the office action mailed on July 29, 2009.

Amendments

1. Please amend claim 1 as shown in the enclosed document. The amendment restricts the method to a preferred concentration range of the copolymer of 0.3 to 10 wt%, as supported in the specification (page 12, line 3).

Claim Rejections – 35 USC §112

2. Claim 9 has been amended to address the Examiner's rejection, which rejection is now believed to be moot.

Claim Rejections – 35 USC §102

3. The Examiner rejects claims 1-13, 15, and 17 as being anticipated by Kang et al. (J. Am. Soc. 2003, 125, 5650-1). The Applicant respectfully traverses the Examiner's rejection, as explained below.

4. Kang et al. discloses a method of preparing a dispersion of single-walled carbon nanotubes (SWNTs), comprising

i) dissolving a block copolymer (line 11, col. 1, page 5650) comprising polyacrylamide to a concentration of between 10^{-3} and 10^{-7} g/ml (line 38, col. 1, page 5650);
ii) suspending SWNTs in the copolymer solution under ultrasonication (line 27, col. 1, page 5650);
iii) micellizating the copolymer by adding water to the mixture (line 27, col. 1, page 5650);

iv) permanently cross-linking the micelles with diamine linkers, using carbodiimide [in order to form amide bonds] (line 36, col. 1, page 5650), thereby encasing the nanotubes within the micelles;
v) dialyzing the mixture to remove the reagents (line 38, col. 1, page 5650); and
vi) centrifuging in three or more consecutive cycles to remove empty micelles.

The present invention provides a method of preparing a dispersion of single-walled carbon nanotubes (SWNTs), comprising

a) adding to a fluid medium a material comprising carbon nanotubes, possibly multi-wall nanotubes (MWNTs);
b) adding to said medium, before or after adding said nanotubes, a block copolymer in a concentration of between 0.3 wt% and 10 wt%;
c) stirring the mixture.

A comparison between the above two methods shows that the present method, as described in the amended claims, attains its goal without employing even one of the Kang's six critical steps. The present method is capable to provide de-agglomerated carbon nanotubes in a concentration of up to 50-60 wt% (nanotubes/copolymer, line 22 on page 4), compared to Kang's method which yields a concentration of about 6 wt% [5 wt% tubes (line 2, col. 2, page 5650) plus less than 1 g polymer (up to 10^{-3} g/ml)]. The huge potential of the present method in providing stable concentrated SWNT dispersions, and a great advantage over the prior methods, is obvious. Moreover, the present method is much simpler than Kang's process consisting of many physical and chemical stages.

5. In view of the above comparison it is respectfully submitted that the present method is novel over the cited prior art.

6. Beside the above said, the applicant further notes that Kang process requires the presence of water and is not applicable to purely organic solvents (micelles only form when enough water is added to the organic solvent). In applications that are sensitive to the presence of water (conjugated polymers for example) this is a major problem.

Moreover, in the Kang process, two adjacent tubes can not form a contact important in electronic applications, where a conductive percolating network of the tubes must be formed to allow for electron transfer between tubes. This is important in various applications requiring the interaction between the bare surface of the tubes and the matrix.

Non-obviousness of the present invention

7. The present method differs from Kang et al. in employing higher copolymer concentration: more than 0.3 - 10 wt% compared to 0.00001 - 0.1 wt%. Furthermore, the present invention enables to utilize carbon nanotubes much more efficiently in desired techniques, due to the following differences:

* No covalent bonding is employed, which makes the technique much simpler and more versatile.

* The carbon nanotubes are not encased and restricted within permanent micellar structures and may be contacted by other components, chemical and electrical, when necessary.
* Not only expensive SWNTs, but also MWNTs can be utilized in the present technique (Examples 6 and 9 of the instant specification).
* The fluid medium of instant method comprises a single solvent, preferably selected from alcohols and alkanes, while Kang et al. excludes such solvents (line 37, col. 1, page 5651) and teaches dimethylformamide (line 24, col. 1, page 5650).
* The instant method provides readily available de-agglomerated tubes without laborious repeated steps of dialysis and centrifugation.

8. The complex chemical process of Kang et al., comprising the creation of cages for entrapping the carbon nanotubes and further formation of amidic bonds, followed by complex purification and separation procedures, would not have led a person skilled in the art to the present method of simple stirring carbon nanotubes with a block copolymer at a concentration of 0.3-10 wt%, resulting in a suspension of carbon nanotubes of a concentration up to 60 wt% (tubes+copolymer) – stable for more than 1000 hours (line 29 on page 6). Therefore it is believed that the present technique as defined in claim 1 is non-obvious in view of Kang et al.

Preferred copolymers (claims 7 and 16) and fluids for said stirring (claims 4 and 17) are disclosed, but the invention as defined in amended claim 1 is believed to be novel and non-obvious even without including said preferred conditions.

Claim Rejections – 35 USC §103

9. The Examiner rejects claim 14 as being unpatentable over Kang et al. in view of WO 02/076888.

The polymer employed in WO/888 is a hydrophilic polymer chosen from polysaccharides and polypeptides, preferably a polysaccharide (page 6). Combining the complex chemical method of Kang et al. with a hydrophilic polymer of WO/88 would have hardly provide the instant simple method of providing concentrated suspensions as described in claim 14.

Nevertheless, claim 14 depends from claim 1 which is believed to be non-obvious (par. 7 above), and so also claim 14 is believed to be non-obvious.

10. The Examiner rejects claim 15 as being unpatentable over Kang et al. in view of Stupp et al. (US 6,890,654).

Stupp et al. are cited as teaching the ratio of copolymer to carbon tubes. However, the Examiner's attention is respectfully directed to the fact that Stupp's ratio is much bigger than the ratio defined in instant claim 15. While claim 15 recites the mass ratio of the copolymer to the tubes from 1:20 to 20:1, Stupp et al. teach at least 50:1 (and even up to 1000:1) which does not overlap with and is greater than the instant range.

Nevertheless, claim 15 depends from claim 1 which is believed to be non-obvious, and so also claim 15 is believed to be non-obvious.

Conclusion

11. In view of the amendment and the above explanations, the present claims are believed to be novel and non-obvious over the cited prior art, and their allowance is respectfully expected.

Respectfully submitted

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